TS-SSC 91-229

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DCA311 Production Summary

DCA311 is the second SSC 50 mm aperture collider dipole magnet to be built at Fermilab. The first magnet, DCA310, was built with practice conductor and was never cryostated, so DCA311 will be the first to be tested cold. Its assembly followed the baseline as stated in the 50 mm Collider Dipole Magnet Requirements and Specifications Book[1] (the Yellow Book). This report will summarize the production history of DCA311 and note any major discrepancies from the baseline design, however it is not a complete discussion of all "Discrepancy Reports". A number of references will be made to DCA311's Specific Data Summary Traveler (SDST) and to the Fermilab Advanced Magnet R&D group's technical note series.

Winding of the coils for DCA311 began on May 15, 1991. One outer coil, 15M-50-2003 was damaged and rejected when a shim slipped out of place and crushed the cable during curing. (This shim was only in use because the final tooling had not yet been completed. When the production tooling was installed the potential for this problem disappeared.) Two metal chips were discovered and removed from the outer surface of coils 15M-50-1003 and 15M-50-2004 before they could cause permanent damage. The averages of the azimuthal measurements, taken in three inch sections along the length of the inner coils, were 10.4 and 9.4 mils relative to the steel master block, with standard deviations of 1.1 mils. Azimuthal measurements of the outer coils resulted in averages of -2.3 and -3.7 mils with standard deviations of 1.2 mils. The longitudinal distribution of the azimuthal size variations is reproducible from coil to coil, as can be seen in the plots in the SDST. These azimuthal sizes were adequate to provide post-collaring prestresses in the desired ranges (8-12 kpsi for the inner coils and 6-10 kpsi for the outer coils).

Since this was one of the first magnets in this series to be assembled, the relative longitudinal shrinkage rates of the inner and outer coils was not well understood, nor was the best time or the step by step procedure for making the outer to outer coil splice (the j-splice) well established. As a result, the coils were assembled with their ends misaligned and with the ends of the G-10 saddle pieces uneven. The protruding saddle pieces were cut off with a hack saw, resulting in final collared coil assemblies 1/2 inch short relative to the design length of the shell. This discrepancy required the set screws, which provide the end load to the coils from the end plate, to be longer, but should not cause any performance problems. Several voltage tap wires were cut accidentally by the hack saw, but were subsequently repaired.

The collaring of magnet DCA311 on 6-18-91 went smoothly. A prestress history plot can be found in the SDST, along with a memo indicating the position of the 2 collar gauge packs relative to the maximum and minimum of the summed azimuthal size of the inner coils. The collar gauges indicate that the maximum inner (outer) coil stresses were about 14 kpsi (12 kpsi) and the final stresses after collaring were about 10.5 kpsi (6.7 kpsi). One interesting feature is the large inner coil prestress loss, 2-2.5 kpsi, between collaring and 7-25-91. This may be due to creep of the kapton insulation. Measurements of the collared coil diameter show little variation along the length of the magnet[2], implying that there is not a large axial position dependence of the prestress

The collet end clamp[3] on the return end of DCA311 was installed and removed twice. One of these removals was to repair a turn to turn short in an outer coil at the return end[4]. The short was between the two outer turns and was apparently caused by a strand which had popped out of place. This short was successfully repaired by slipping a piece of kapton between the turns.

The stainless steel magnet shell was welded between August 9 and 14, 1991. The yoke packs on DCA311 were configured with 4 approximately 12 foot long packs, with 98% packing factor, sandwiched between two 10 inch long monolithic packs. Short, ≈10 inch long filler packs were also positioned at both ends. This configuration was unstable and lead to either a chevronning or belvilling of the yokes which manifested itself in a reduction in the diameter of the welded shell[5]. A plot showing this effect is in the SDST. This also resulted in a decrease in the shell tension and probably reduced the clamping force of the yokes on the collars[6]. The problem was corrected in following magnets by increasing the packing factor to 99% and placing additional monolithic packs between each of the long packs[7].

The electrical interconnect work was delayed when the power bus failed its hipot test, requiring MIT to modify their design and have a new bus manufactured.

During the final assembly of DCA310 it was discovered that when the extension tube was welded on the end plate, the end force increased to approximately 12 klbs, well above the desired range of 2-4 klbs. It is believed shrinkage of the large amount of weld material used making this weld results in warpage of the end plate, forcing the bushing screws against the bullets and increasing the force[8]. The welding procedure was reviewed and the welders were instructed as to what modifications in their technique might lead to less end plate warpage. Measurements of the force increase during welding were made on DCA311. Again the final end force was too high and the bushing screws were readjusted through the port holes in the extension tube, to a final value of ≈ 4 klbs. A plot of the measured end forces can be found in the SDST. The lead end set screws were pre-adjusted to give this same force, since they cannot be adjusted once the extension tube is welded in place.

No major problems were encountered during the cryostating of DCA311, however there were several minor discrepancies. Two of these merit some discussion. First, a 20 K MLI ring built to the wrong revision (9.5 inch diameter instead of 12 inch diameter) was used. However, the heat load increase due to the smaller diameter ring is believed to be negligible. Second, a survey of the x, y and z positions of the piping indicated that most were out of tolerance. This was due to the unavailability of the appropriate fixtures needed to assist in the positioning of the pipes during the assembly. These out of tolerance conditions did not lead to problems during hook-up at the Fermilab Magnet Test Facility however they may if this magnet is ever used elsewhere. Alignment fixtures are now available and will be used during the assembly of future magnets.

Assembly of the magnet was completed and DCA311 was shipped to the Fermilab Magnet Test Facility on November 1, 1991. It exceeded its operating field on the first attempt on November 12, 1991.

In summary, DCA311 had no major assembly anomalies which would affect its mechanical performance. The misalignment of the coil ends and the chevronning of the yoke packs may result in the field quality of this magnet not being representative of future magnets.

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